DIVISION OF FISH AND GAME OF CALIFORNIA
BUREAU OF COMMERCIAL FISHERIES

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Fishing Localities for the California Sardine, *Sardinops caerulea*, 1928-1936

By
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FISHING LOCALITIES FOR THE CALIFORNIA SARDINE, *SARDINOPS CAERULEA*, 1928-1936[1]

By FRANCES N. CLARK

INTRODUCTION

A knowledge of the localities in which fish are caught comprises an important phase in the investigation of any great fishery. Changes in the fishing grounds frequently have a significant bearing on the question of overfishing, and as a rule, the location of the fishing grounds is intimately connected with the biology of the species involved. Because of these factors, the program for the investigation of the California sardine includes the gathering of information about the locality in which individual catches are made by commercial fishermen. This investigation was inaugurated in 1919 and has been continued without interruption. The first ten years, 1919 to 1929, covered the period of rapid expansion experienced by the industry following its initial impetus furnished by the World War. The detailed findings for this time interval have been published previously.[2]

During this ten-year period the fishing grounds were rapidly extended from the local areas immediately adjacent to the canneries located at Monterey, San Pedro and San Diego to distant grounds, 30, 40, and even 60 miles from port. Because of this rapid initial growth, the succeeding seven seasons, 1929-30 to 1935-36, have seen little addition to the previously exploited fishing areas. The one exception is the development of the fishing grounds off San Francisco. In 1928-29 only one cannery was operating in the San Francisco region, but by 1935-36 the San Francisco Bay ports comprised one of the three important sardine fishing centers of the State. As a result, a fleet of boats is now operating out of San Francisco and exploiting new fishing grounds as well as fishing those frequented by Monterey boats. The grounds fished by the Monterey, San Pedro and San Diego fleets have changed but little. If in the future new canning centers are developed, new grounds adjacent to these centers will probably be utilized but it seems unlikely that any new localities will be fished extensively in the vicinity of the present canning ports.

Because of this lack of change, the time is opportune to compare the areas covered by the sardine fishermen throughout the entire state and to attempt to point out the association of these fishing grounds with oceanic depth contours and with distances from ports and shore lines.

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[1] Contribution No. 158 from the California State Fisheries Laboratory, August, 1936. *Sardinops* is here used to designate the California sardine in accordance with the reclassification of the Pacific sardines made by Hubbs, Proc. California Acad. Sci., *18*, pp. 261-265, 1929.

[2] California State Fisheries Laboratory

1926. The California sardine. Calif. Div. Fish & Game, Fish Bull., no. 11, 221 pp.

1930. Fishing areas along the California Coast for the sardine (*Sardina caerulea*). Calif. Div. Fish & Game, Fish Bull., no. 25, 44 pp.

AVAILABLE MATERIAL

Two sources of material are available for this study. The first is the data collected by the staff of the California State Fisheries Laboratory over the period of years covered by the investigation. The cannery catch of sardines has been sampled continuously since 1919. These samples are secured from five different boats each half week, making ten samples per week during each sardine season. At the same time that a sample of fish is taken, the investigator questions the boat captain or some other crew member about where he made his catch. In most cases the information thus obtained is sufficiently adequate to make possible a definite location of the catch and to show the distance off shore that the fishermen were operating when the catch was made.

The previous publications based on these data discuss in detail the development and expansion of the fishing grounds and point out the changes in fishing localities which occur within each season. Since 1929 the same grounds have been exploited as in former years and the same seasonal variations have occurred. There is nothing to be gained, therefore, in a presentation of these details for the later seasons. For this reason this paper consists of a general discussion of the fishing grounds, based on the last eight seasons' data, 1928-29 to 1935-36. This serves to pick up the story where the former publications left off and to depict the fishing areas from a broader aspect.

Through lack of personnel it has not been possible to collect the detailed information about the San Francisco and San Diego fisheries that has been accumulated about the areas fished from the ports of Monterey and San Pedro. Our second source of material, however, gives us some information about the San Francisco and San Diego grounds.

In 1934 the waters adjacent to the California coast were divided into numbered blocks comprising 10 minutes of latitude and longitude. The fishermen are requested to report the locality of their catch by these numbered blocks. For the sardine fishery, the California Division of Fish and Game maintains checkers at each fishing port. These checkers, as far as possible, observe the unloading of each boat load of fish delivered, record the tonnage, and in addition inquire and record the number of the block where the catch was made. The accuracy of these records has been checked by direct comparison with the more detailed information secured by the scientific investigators for a limited number of boat loads. By 1935-36, the system had been perfected to the point where the percentage of difference is less than 10. The comparisons show also that the errors that do occur are compensatory and not accumulative.

This source of data has been used in this study, therefore, to show the tonnages taken in the 1935-36 season from each of the numbered blocks along the California coast. San Francisco and Monterey fishermen frequently operate on the same fishing grounds and similarly in the southern part of the State the San Pedro and San Diego fishing areas overlap. The data here shown, therefore, indicate the tonnages taken from a specific block without regard to the port of delivery.

CATCH LOCALITIES OF SARDINES
LANDED AT
LOS ANGELES AND MONTEREY HARBORS
1928-1936
WITH
OCEAN DEPTHS IN 100 FATHOM INTERVALS
FROM 100 TO 500 FATHOMS
N
W
E
S
Pt. Reyes
Farallon Is.
OAKLAND
SAN FRANCISCO
Pt. Montara
Pigeon Pt.
SANTA CRUZ
MONTEREY
Pt. Sur
Piedres Blancas
Pt. Buchon
Pt. Conception
SANTA BARBARA
S. Miguel I.
S. Rosa I.
S. Cruz I.
Pt. Dume
LOS ANGELES
Pt. Vincente
SAN PEDRO
Pt. Fermin
S. Barbara Id.
S. Nicolas I.
S. Catalina I.
S. Clemente I.
OCEANSIDE
SAN DIEGO
BOUNDRY
Los Coronados
PACIFIC OCEAN

FIG. 1

RELATION OF THE CATCH TO FATHOM CONTOURS

Central California

In figure 1 are shown the locations of specific sardine catches as recorded by the investigators throughout the seasons from 1928-29 to 1935-36. The catches in the San Francisco-Monterey region represent deliveries to Monterey only. Monterey fishermen are now operating as far north as Point Reyes and some catches have been made as far south as Point Sur, but the majority of the catches are made within Monterey Bay. This is to be expected because of its closer proximity to port and because the fishermen must cruise through the bay to get to more distant grounds. There are three definite areas of concentration within the bay: off Monterey, the central portion over the submerged valley of the Salinas River, and off Santa Cruz. The intensive fishing adjacent to the town of Monterey is easily explained by its close proximity to port but no simple reason is apparent for the other two areas.

Outside the bay there is an evident tendency for the catches to be made off the headlands. This might result from the fact that when a fisherman gives the location of a catch he is apt to orient it in relation to a headland. The same concentration, however, is again shown in figure 2, which gives the catch by tons according to numbered blocks. For these data the fishermen reported the locality by block number and consequently should not have been influenced greatly by the headlands.

One of the most striking phases of the Monterey fishery is that practically no catches were made beyond the 100-fathom line or continental shelf. The shelf widens off San Francisco and correspondingly more catches are made at greater distances from shore, but as the shelf narrows toward Monterey the catches occur within a narrower radius adjacent to the coast. The same situation is indicated in figure 2 where the number of tons per block decreases rapidly at and outside the 100-fathom line.

This confinement of the fishing grounds to the continental shelf may result from several causes. The most obvious explanation is that the sardine population is chiefly found in water of 100 fathoms or less. The mere location of fishing grounds, however, does not prove this point. At greater depths fishing conditions may not be as favorable. Another complicating factor is that the fishermen prefer to navigate by points along the shore and may be reluctant to search for fish at extended distances from shore. This, however, should not keep the fishing boats closer to shore in the Monterey region than off San Francisco and can probably be dismissed as a cause for confining the Monterey sardine fishing to the continental shelf. There remain, therefore, two possible explanations, either the fishing conditions are unfavorable beyond the 100-fathom line or the sardine population is chiefly found relatively close to shore. All data at hand indicate that the latter is the more probable explanation.

Southern California

In southern California the oceanic depth contours are more complex and the distribution of the catches is correspondingly difficult to

analyze. In figure 1 the data show the location of specific catches made by fishermen operating out of San Pedro from 1928-29 to 1935-36, and a few catches made by boats fishing out of San Diego.

The fishing grounds lie between Point Conception on the north and Los Coronados Islands on the south, and extend seaward as far as Santa Rosa and San Nicolas islands. The tendency for the catches to be concentrated off headlands is not clearly evident except in the vicinity of Point Vicente. Here, within a very limited mileage, thousands of tons of sardines are taken each fishing season. Furthermore, the southern California fishing grounds differ from those of the central part of the State in that they are not confined to the continental shelf. Because the 100-fathom line lies much closer to shore, it does not present the broad expanse of fishing area to be found to the north, but even where the shelf is fairly wide there occurs no great proportion of the catches. On the other hand, the catches appear to be concentrated on the steep outer slope of the shelf where it drops rapidly to the 500-fathom line. This is suggested in the high percentage of catches occurring immediately south of San Pedro, off Point Vicente, off Point Dume, to a lesser extent off Point Hueneme, and again on the fishing grounds between Santa Catalina and Santa Barbara islands.

Throughout the entire southern California fishing region, very few catches were made over depths greater than 500 fathoms. This would appear to indicate that here the sardine population is also confined to the more shallow waters. While cruising to the more distant fishing grounds, the fishermen many times pass over regions of greater depths and, with favorable fishing conditions, if sardines were to be found in equal abundance in these regions, more catches should be made in waters deeper than 500 fathoms. This concentration of the catch along the edge of the continental shelf is further suggested by the records of tons per numbered block as shown in figure 2.

It would be possible to speculate extensively about why the sardine population may occur in greatest abundance over or at the edge of the continental shelf but our knowledge of oceanic conditions is too limited to justify such a discussion. The distribution of food is presumably the determining factor since plankton appears to be more abundant over areas of upwelling of colder bottom waters. However, we know very little about that problem, and this study can only show with fair accuracy where sardines are caught without explaining why fishing occurs in certain localities and not in others.

RELATION OF THE CATCH TO DISTANCE FROM SHORE

In the administration of a marine fishery, there is always with us the moot question of how great a proportion of the fishing grounds lies within the three-mile limit. This is especially true in southern California where the commercial and sport fishing grounds overlap. To determine what this proportion is in the sardine fishery, the data obtained for the Monterey and San Pedro fisheries have been analyzed to show the distance each catch lies off shore.

The same catch localities given in figure 1 are again indicated in figure 3, which also shows the three-mile limit. Precedent has established that the state controls marine waters to a distance of three miles

CALIFORNIA SARDINE CATCH
TONS TAKEN PER NUMBERED BLOCK
1935-1936 SEASON
LEGEND
30,000 - 40,000 TONS
20,000 - 30,000 TONS
10,000 - 20,000 TONS
1,000 - 10,000 TONS
500 - 1,000 TONS
100 - 500 TONS
0 - 100 TONS
N
W
E
S
Pt. Arena
100 FATHOM
Pt. Reyes
Farallon I.
SAN FRANCISCO
Pt Montara
Pigeon Pt.
SANTA CRUZ
MONTEREY
Pt. Sur
Piedres Blancas
Pt. Buchon
60 FATHOM
Pt. Conception
San Miguel I.
Santa Rosa
Santa Cruz I.
Pt. Dume
LOS ANGELES
Vincente
Santa Barbara I.
San Nicolas I.
Santa Catalina I.
OCEANSIDE
San Clemente I.
SAN DIEGO
PACIFIC OCEAN

FIG 2

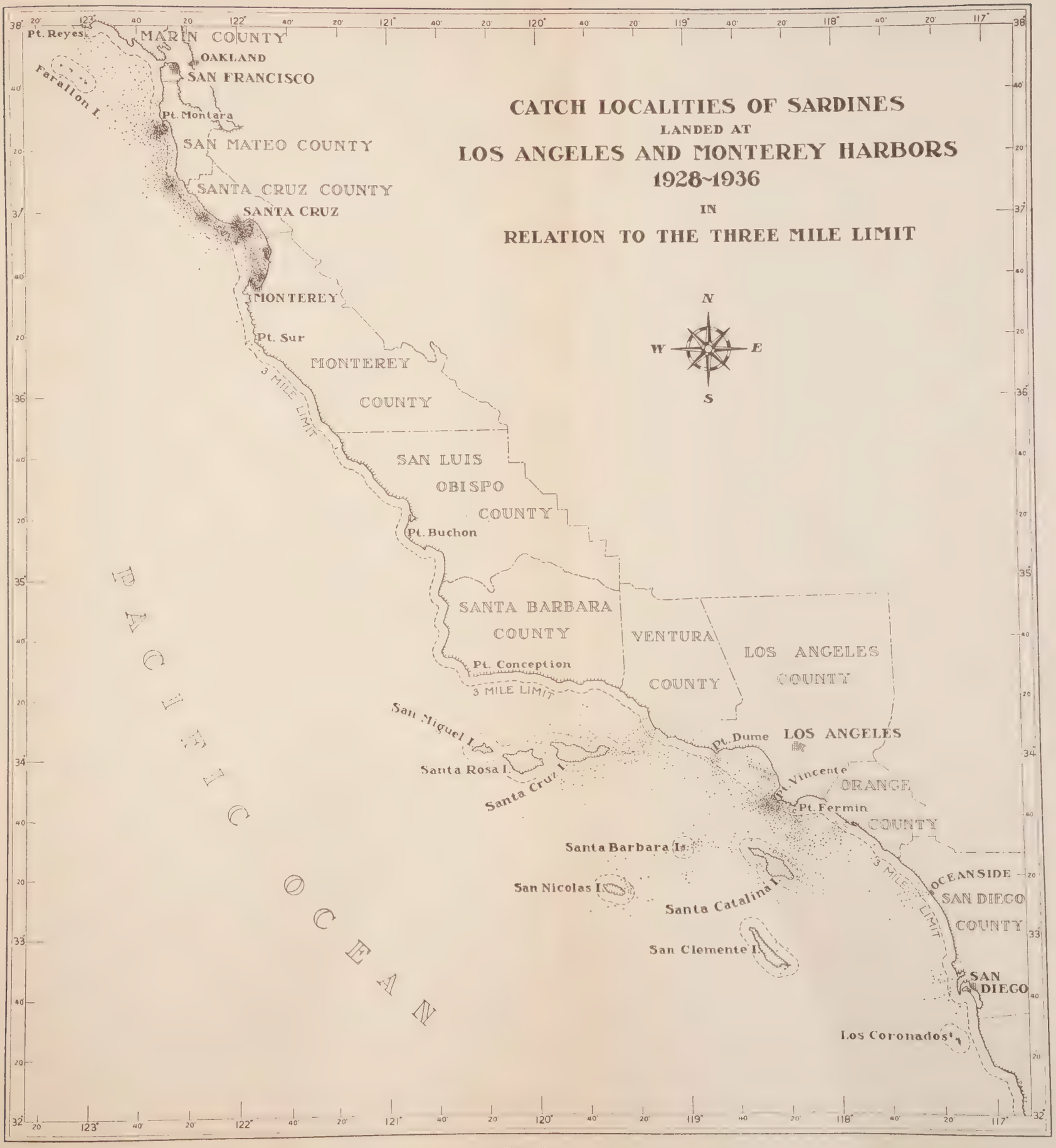
CATCH LOCALITIES OF SARDINES
LANDED AT
LOS ANGELES AND MONTEREY HARBORS
1928-1936
IN
RELATION TO THE THREE MILE LIMIT
N
W
E
S
Pt. Reyes
MARIN COUNTY
OAKLAND
SAN FRANCISCO
Farallon I.
Pt. Montara
SAN MATEO COUNTY
SANTA CRUZ COUNTY
SANTA CRUZ
MONTEREY
Pt. Sur
MONTEREY
COUNTY
3 MILE LIMIT
SAN LUIS
OBISPO
COUNTY
Pt. Buchon
SANTA BARBARA
COUNTY
Pt. Conception
3 MILE LIMIT
VENTURA
COUNTY
LOS ANGELES
COUNTY
Pt. Dume
LOS ANGELES
San Miguel I.
Santa Rosa I.
Santa Cruz I.
Pt. Vincente
ORANGE
COUNTY
Pt. Fermin
Santa Barbara Is.
San Nicolas I.
Santa Catalina I.
San Clemente I.
3 MILE LIMIT
OCEANSIDE
SAN DIEGO
COUNTY
SAN
DIEGO
Los Coronados
PACIFIC OCEAN

FIG. 3

from shore, and also all bays to three miles beyond a line drawn from headland to headland. Thus all of Monterey and Santa Monica bays are within State waters.

Figure 3 indicates that much of the Monterey fishery lies within Monterey Bay. In addition, many of the catches made north or south of the bay are within three miles from shore. For the Monterey fishery from 1928-29 to 1935-36, 75 per cent of the 1404 catches, for which we have definite information, were made inside the three-mile limit, including the bay. Of the catches not made in the bay, 45 per cent were within the three-mile limit.

For the San Pedro fishery from 1928-29 to 1935-36, 38 per cent of the 734 catches comprising our available data occurred within three miles from shore and within Santa Monica Bay. The occurrence of catches close to shore is especially to be noted in the Point Vicente area. On the other hand, to the south of San Pedro along the mainland, the proportion of catches within three miles from shore is relatively small.

To further illustrate the relation of the sardine fishing to the shore line, figures 4 and 5 were prepared. For these figures the percentage of catches within each mile from the shore of either the islands or the mainland were calculated. The catches within Monterey and Santa Monica bays were measured from the shore line without regard to the legal three-mile limit. In both the Monterey and the San Pedro fishery, no catches were made more than 18 miles from the coast, and over half of all catches were made within five miles or less of the shore line. This concentration close to land is more marked in the Monterey fishery than in the San Pedro fishery. Within Monterey Bay much fishing takes place very close to the sandy beaches, but even north of the bay 77 per cent of the catches were made within five miles or less of the shore line.

The scanty data available for the San Francisco and San Diego fisheries suggest that the fishing for large sardines from these two ports is carried on at greater distances from shore but for these regions also much fishing occurs within three miles of the shore. This is especially true for San Francisco where the heaviest tonnages are taken near Point Montara and where catches occur within three miles of the Farallon Islands.

The data here presented indicate that a large proportion of the sardine fishing off Marin and San Francisco counties occurs outside the three-mile limit. Off San Mateo, Santa Cruz and Monterey counties, on the other hand, much of the fishing is quite close to shore.

In southern California very little fishing occurs near the mainland of Santa Barbara County, but many catches are made near Santa Cruz and Anacapa islands, which are also part of this county. Off Ventura and Los Angeles counties, about fifty per cent of the fishing for the canneries and reduction plants occurs within three miles of the mainland and in the Point Vicente area more than half. Off Orange and San Diego counties, the sardine fishing grounds lie farther off shore and only about twenty per cent of the catches for adult sardines are made within the three-mile limit. On the other hand, throughout southern California the fishery for young fish of the sizes used for bait and the "quarter-oil" pack occasionally put up at San Diego is carried on very close to shore.

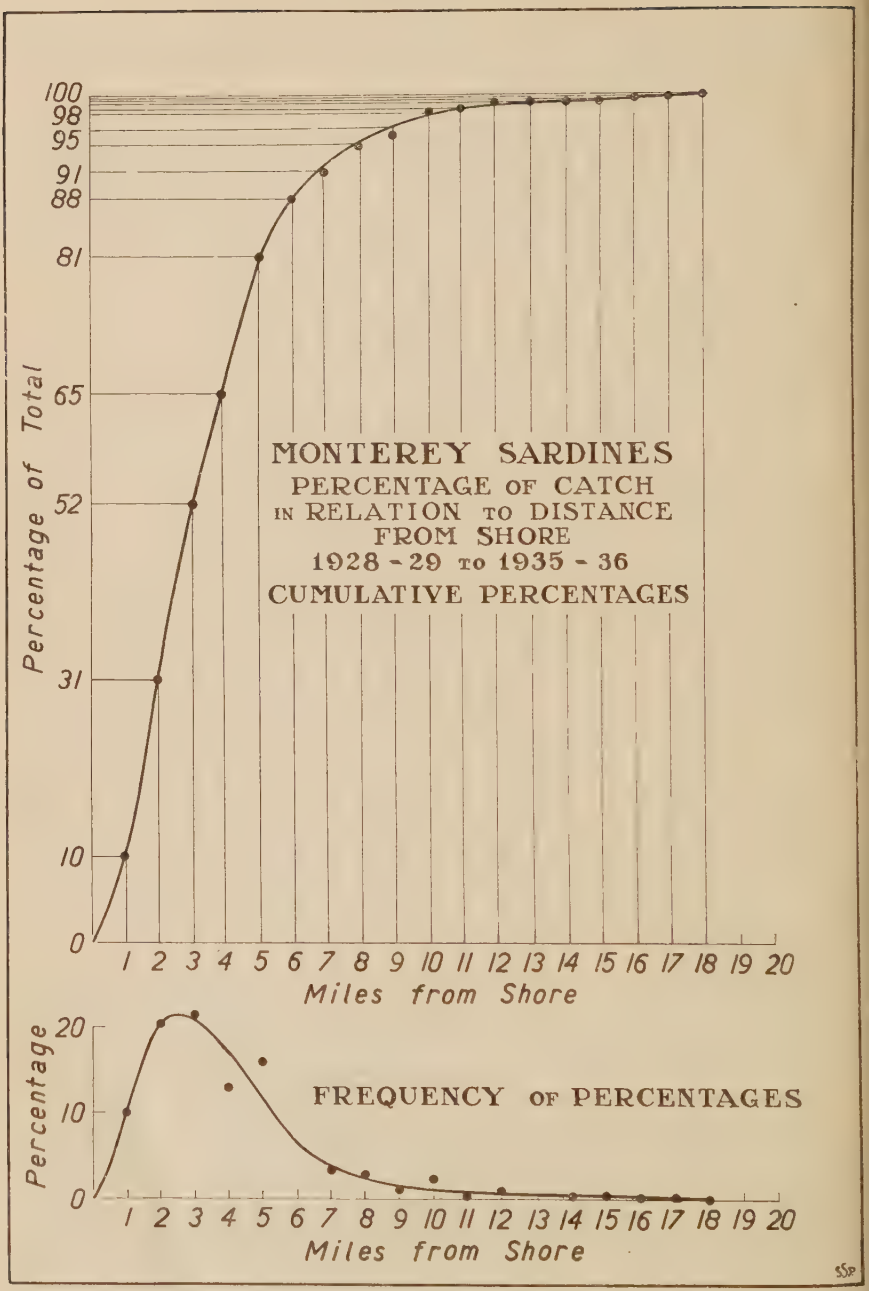

FIG. 4. Relation of the Monterey sardine catch to the distance from shore. In the upper curve the values have been accumulated to show the percentage of catches between the shore line and each additional mile off shore, *e. g.*, 10 per cent of the catches occurred between the shore line and 1 mile off, 81 per cent between shore and 5 miles off, and 100 per cent or all catches between the shore and 18 miles off. The lower curve shows the percentage of catches made within each mile from shore, *e.g.*, 10 per cent of the catches were between shore line and 1 mile off, 20 per cent between 1 and 2 miles off, 21 per cent between 2 and 3 miles. The curves have been fitted to the data by eye.

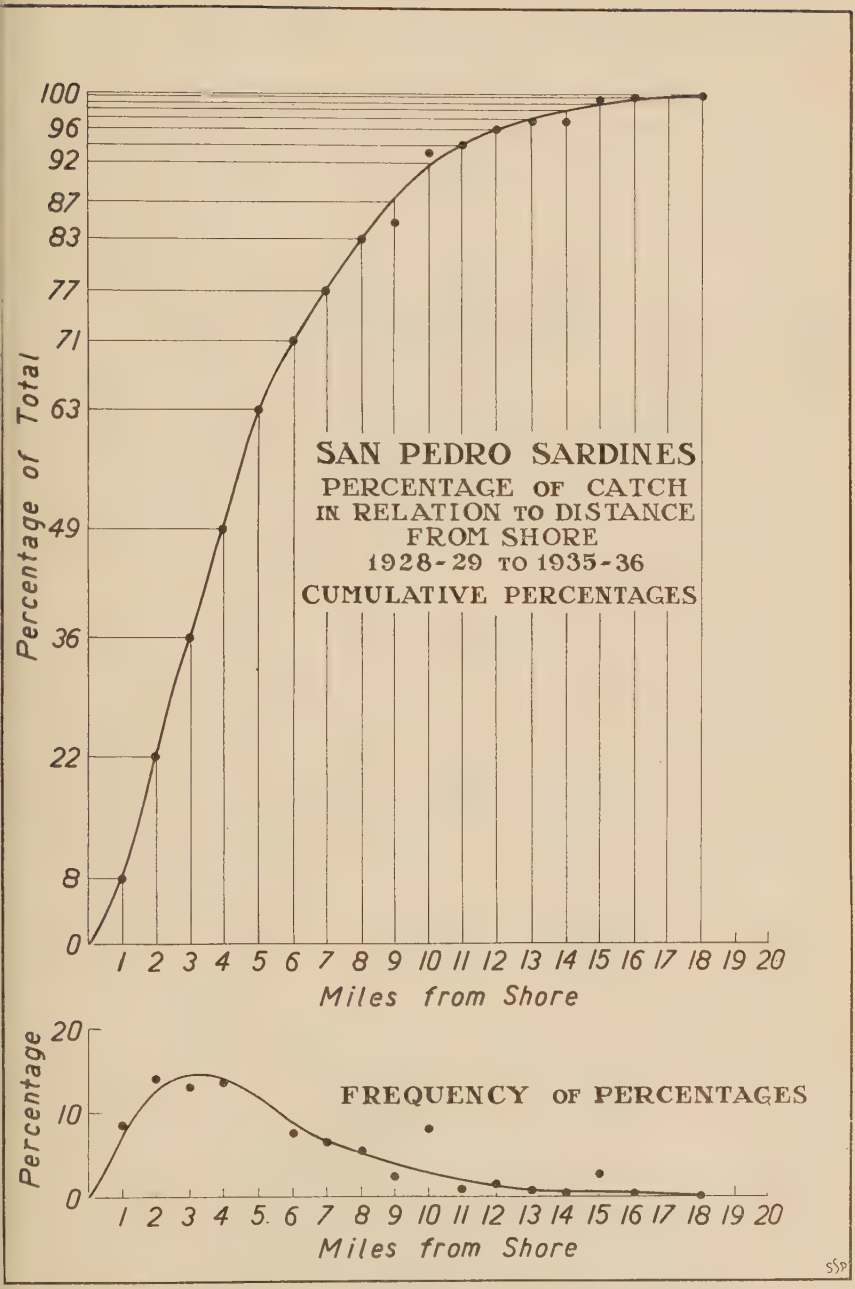

FIG. 5. Relation of the San Pedro sardine catch to the distance from shore. In the upper curve the values have been accumulated to show the percentage of catches between the shore line and each additional mile off shore, *e.g.*, 8 per cent of the catches occurred between the shore line and 1 mile off, 63 per cent between shore and 5 miles off, and 100 per cent or all catches between the shore and 18 miles off. The lower curve shows the percentage of catches made within each mile from shore, *e.g.*, 8 per cent of the catches were made between shore line and 1 mile off, 14 per cent between 1 and 2 miles off, 13 per cent between 2 and 3 miles. The curves have been fitted to the data by eye.

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